Evaluation of problems and possible solutions linked to the surveillance and control of bovine brucellosis in sub-Saharan Africa, with special emphasis on Nigeria

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Summary

Bovine brucellosis is disease of economic and public health significance in sub-Saharan Africa. The disease is distributed worldwide but some countries have been able to eradicate brucellosis from their territories using elaborate brucellosis control and eradication programmes that have been targeted primarily at livestock (the main reservoir host for the disease). This has been achieved mainly by vaccination, test and slaughter, as well as by regular surveillance for early detection of the disease. Despite the level of knowledge on the epidemiology of bovine brucellosis, there has been limited success in controlling bovine brucellosis in sub-Saharan Africa. Some of the problems associated with the surveillance and control of bovine brucellosis in sub-Saharan Africa include poor disease reporting, insufficient financial resources of governments (poor economic status of most countries in sub-Saharan Africa), as well as competing national health priorities, inadequate infrastructures and personnel, the commonly practised seasonal grazing or transhumant husbandry systems and communal grazing, inadequate monitoring of the disease in wildlife and poor communication and education of stakeholders. Since previous attempts at the control of bovine brucellosis have failed in Africa, it was considered important to address this aspect, using an approach that differed from the classic veterinary regulatory approach. Possible ways of dealing with this problem using complementary measures to the conventional approaches are also proposed.

Keywords

Africa, Bovine, Brucellosis, Control, Cooperation, Nigeria, Public health.

Sorveglianza e controllo della brucellosi bovina nell'Africa sub-Sahariana con particolare riferimento alla Nigeria: valutazione dei problemi e possibili soluzioni

Riassunto

Nell'Africa sub-Sahariana la brucellosi bovina è una malattia di rilievo economico e con ricadute sulla salute pubblica. Distribuita su scala mondiale, la brucellosi è stata eradicata in alcuni Paesi attraverso l'elaborazione di programmi di controllo e eradicazione indirizzati in primo luogo al bestiame (il principale ospite reservoir della malattia).L'obiettivo è stato raggiunto principal-mente attraverso la vaccinazione, i test e la

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macellazione oltre a programmi di sorveglianza programmati per l'allerta precoce della malattia. Nonostante le conoscenze acquisite sull'epidemiologia della brucellosi bovina, nell'Africa sub-Sahariana il controllo della brucellosi bovina è risultato limitato. Le problematiche associate alla sorveglianza e al controllo di questa malattia in Africa sub-Sahariana sono riconducibili a scarse comunicazioni riguardo la patologia, insufficienti risorse finanziarie dei governi (status economico deficitario della maggior parte dei Paesi sub-Sahariani) oltre a competitive priorità di salute pubblica, infrastrutture e personale inadeguati, pascoli stagionali comunemente praticati o sistemi di allevamento transumante e pascoli comunali, inadeguato monitoraggio della malattia nei selvatici e scarsa comunicazione e preparazione del personale addetto. Poiché in Africa i tentativi di controllo della brucellosi bovina sono falliti, si ritiene importante riconsiderare questo aspetto utilizzando un approccio diverso da quello veterinario classico. Si propongono, inoltre, modalità alternative di soluzione del problema utilizzando misure complementari ai tradizionali approcci.

Parole chiave

Africa sub-Sahariana, Bovino, Brucellosi, Controllo, Cooperazione intersettoriale, Nigeria, Salute pubblica.

Introduction

Bovine brucellosis is caused chiefly by *Brucella abortus* which is a small, non-motile, Gram-negative, non-sporulating, non-encapsulated coccobacillus or short rod (12). It is a facultative intracellular pathogen (23, 38). The organism is able to survive and multiply in the tissues of the reticulo-endothelial system (26, 30), phagocytic cells and lymphoid tissues given the fact that they are able to prevent fusion of the lysosome with the phagosome (4, 12). Bovine brucellosis is of great socio-economic and public health significance in sub-Saharan Africa (13, 29). The disease is still one of the world's most damaging contagious bacterial zoonoses of ruminants (6, 8, 31). Control and eradication programmes have achieved varying levels of success in different countries for many reasons. The World Health Organization (WHO) estimates that there are 500 000 new cases of human brucellosis every year (26, 27). However, the infection is not sustainable in the human population and the source of human infection is principally from animal reservoirs (13, 38). It is therefore assumed that the effective control of brucellosis in animals will help to achieve control in humans.

Bovine brucellosis has been controlled or eradicated in many countries of the world, including some European countries (11), Australia (2), New Zealand (18), parts of the United States (28) as well as some countries in southern Africa (14). The *Terrestrial animal health code* of the World Organisation for Animal Health (*Office International des Épizooties*: OIE) recommends measures to be taken to control the international spread (by trade, i.e. import and export) of bovine brucellosis worldwide (35) and these measures and their modifications have been employed by developed nations to successfully control the international spread of bovine brucellosis. Despite the depth of knowledge of the epidemiology of bovine brucellosis, most countries in sub-Saharan Africa have failed to control the disease for a number of reasons.

The authors evaluate the current situation and review information on the distribution, surveillance, epidemiology, control and eradication, as well as discuss problems encountered by countries in sub-Saharan Africa in their attempts to manage, control and ultimately eradicate bovine brucellosis. In addition, new approaches are proposed for the control of the disease in sub-Saharan Africa.

Methods

An evaluation of the current situation was performed through a review of publications devoted to worldwide efforts towards the global control of bovine brucellosis. The OIE recommendations on bovine brucellosis control were also assessed for practicability in the African context. The impact of the farming systems of sub-Saharan Africa, as well as the attitudes and specificities of the people, as related to the surveillance, monitoring, reporting and control of the disease were also studied. The experience of the lead author as a government-employed veterinarian and discussions with other state and research veterinarians in Nigeria also contributed to this study.

Results and discussion

Distribution of bovine brucellosis in sub-Saharan Africa

Countries in sub-Saharan Africa have differing levels of prevalence for brucellosis in their livestock populations (14, 35). Based on available reports, brucellosis is known to exist in 40 of the 49 countries in Africa (17). The occurrence of brucellosis (either prevalence or incidence), like most other infectious diseases in sub-Saharan Africa, is, however, underestimated (26), mainly due to poor monitoring and reporting except in southern Africa (14). Bovine brucellosis is a notifiable disease to the OIE. According to the new OIE recommendations, as presented in the recently established World Animal Health Information System (WAHIS), countries are required to make a six-monthly report using the joint Food and Agriculture Organization (FAO)/ World Health Organization (WHO)/ OIE questionnaire (36). These reports are used to compile annual disease data. Details on the occurrence and distribution of bovine brucellosis in sub-Saharan Africa are available on the OIE website.

Cattle farming systems in sub-Saharan Africa

The cattle farming systems in sub-Saharan Africa can be broadly divided into intensive and extensive farming systems. The intensive farming system is very uncommon in most parts of sub-Saharan Africa, except in southern Africa, while the extensive systems are more common and include seasonal or transhumant nomadic farming, sedentary cattle farming and communal farming systems which involve smallholder farmers and the rearing of mixed animal species. These extensive farming systems contribute to the perpetuation of brucellosis in cattle herds in sub-Saharan Africa in many ways when compared to the intensive systems of Europe (22). Cattle farming systems in sub-Saharan Africa can also be divided into seven different classes which include the following:

- pastoral
- agro-pastoral
- mixed semi-arid
- mixed sub-humid
- mixed humid,
- mixed highland
- small holder dairy farming systems (24).

All seven systems constitute the traditional farming systems in sub-Saharan Africa which constitute approximately 90% of the cattle farming systems in sub-Saharan Africa (16). The most common cattle farming system in Nigeria is the pastoral (Fulani transhumant nomads) system and 95% of the entire Nigerian cattle population are farmed using this livestock husbandry system (1). An estimated geographic distribution of the main livestock systems in sub-Saharan Africa has been described by Mangen and co-workers (16).

Disease control problems

Poor disease reporting has been identified as one of the major problems encountered in the control of livestock diseases in most parts of Africa. Bovine brucellosis is no exception (14). Most countries in Africa do not report the status of bovine brucellosis in their territory or, most often, they submit insufficient reports to the OIE. Secondly, reduced government resources, the lack of adequate infrastructures and the scarcity of veterinary personnel all represent key issues in difficulties associated with disease control in countries of Africa south of the Sahara (5, 14, 26). In Africa, the relative importance of human disease is often determined by its degree of acute fatality. Government policies do not appear to support effective brucellosis control in most African nations since it is a chronic infection in humans. Finally, there is poor/inadequate communication between the authorities responsible for reporting animal diseases and human disease in most countries of Africa (7).

Field surveillance

Clinical features

The most common clinical signs of the infection in cattle include abortion storms in naive cattle populations (usually during the last three months of pregnancy), stillbirths and the birth of weak calves and in chronic cases, unilateral or bilateral orchitis, epididymitis and seminal vessiculitis in bulls. Unilateral or bilateral hygromas may also be evident, especially in the carpal joints of chronically infected animals (13). In the field, a number of serological tests can be performed to detect the presence of brucellosis in a cattle herd. The most commonly used rapid screening test is the Rose Bengal plate test (RBPT) (21). Upon post-mortem examination, lesions usually reveal the mottled appearance of the cotyledons in the placenta of infected cows and broncho-pneumonia in the aborted foetus with subcutaneous oedema and blood tinged fluid in the thoracic and abdominal cavities (12).

Effective surveillance of bovine brucellosis at the individual level are often not unsuccessful since most of the available rapid screening tests that can be used in the field (for instance the RBPT and the *Brucella* milk ring tests) have low sensitivity and specificity. In addition, inadequate laboratory infrastructures and poor funding in developing countries may not enable good surveillance; it must be remembered that rural areas are often inaccessible and transhumant animal movements have a negative impact on reliable data collection.

Laboratory surveillance

A number of laboratory tests, including serological tests (RBPT, complement fixation test [CFT] and the enzyme-linked immuno-sorbent assay [ELISA]) are used for laboratory surveillance. The gold standard remains the isolation and identification of the causative organism or its genetic materials i.e. polymerase chain reaction (PCR) and nucleic acid recognition (12, 21, 26). Tissue samples of diagnostic importance for the isolation of the infectious agent or performance of a PCR-based test include foetal membranes, lungs, stomach content, liver and spleen, as well as uterine discharge, colostrum or milk and lymph nodes (usually supramammary) of infected cows (12). Microscopic examination using the Ziehl Neelsen stain modification technique is performed as previously described (34).

The limitations that laboratories in Africa face include the following:

- inadequate diagnostic efficiency of the laboratory-based serological tests; the predictive level of a positive test is relatively low (21); although we are aware that some ELISAs are highly specific and sensitive, they are relatively expensive for countries in sub-Saharan Africa and they require expertise and advanced laboratory skills; furthermore, fresh specimens (which may not be readily available in Africa) are required for effective diagnosis (37)
- culling of non-infected animals due to poor specificity of serological tests at the level of the individual animal is a strategy that is not acceptable culturally in countries where a cow represents a substantial part of the assets of a rural family (14)
- inadequate laboratory backup, poor infrastructures, scarce funding, capacity building problems are associated with maintenance and other organisational constraints; it may not be possible to collect specimens because there are too few veterinarians, to transport specimens long distances over poor roads creates a further obstacle and, when the specimens do reach the laboratory, there may be no equipment, supplies or trained personnel to process the samples or to return reliable results to the veterinarian who submitted them; the culture of the organism is time-consuming and may even be life-threatening in laboratories that have not been constructed properly or in those that have inadequate ventilation systems; the PCR-based assays are relatively expensive and unaffordable for most countries in sub-Saharan Africa (7)
- other micro-organisms resemble the *Brucella* agent under the microscope using the modified Ziehl Neelsen stain, for example, *Coxiella*, *Chlamydophila* and *Nocardia* spp., so smears made and stained in the field are of little diagnostic significance

Epidemiology of bovine brucellosis

Transmission between cattle

The infected animal is the most important source of bovine brucellosis infection (12). A large number of organisms are contained in uterine discharge, the placenta and aborted foetus which results in contamination of the environment (3). Transmission occurs after the ingestion of materials (such as feed and water) that have been contaminated with these products of *Brucella*-induced abortion or the licking of infected placentas, calves, foetuses or genitalia of infected cows soon after abortion or calving (4, 12). Other sources of infection that have been implicated include the inhalation of infectious organisms, conjunctival infection, *in utero* and congenital infection, as well as infected colostrum and milk (19).

Transmission from wildlife species

B. abortus has been reported in the African buffalo (*Syncerus caffer*) (12); this is important since these animals sometimes have contact with domestic cattle. The buffalo is considered to be a reservoir for *B. abortus* in southern Africa (15). While previous workers have recorded between 23% and 48% seropositivity to bovine brucellosis in African buffalo in South Africa and Zimbabwe, other wildlife species, including hippopotamus (*Hippopotamus amphibius*), zebra (*Equus quagga*), eland (*Taurotragus oryx*), waterbuck (*Kobus ellipsiprymnus*) and impala (*Aepyceros melampus*) have been tested and have revealed seropositivity for brucellosis but are not considered important in the epidemiology of brucellosis in southern Africa as these animals are not frequently in contact with cattle (10).

The true prevalence of brucellosis in wildlife in Nigeria and many other sub-Saharan African countries is not known and this is of major concern in regard to the control of brucellosis in sub-Saharan Africa (1).

Control of bovine brucellosis in sub-Saharan Africa

Proposed solutions for the bovine brucellosis situation in sub-Saharan Africa

The recommended approach to the control of bovine brucellosis worldwide includes regular surveillance, mass vaccination and testing and segregation or slaughter (9, 19, 20). This is achieved by a number of approaches which will not be discussed in this study. However, past experience has shown that this approach is impracticable in Africa as a result of problems discussed earlier.

To be able to control brucellosis in sub-Saharan Africa, it is necessary to consider how policy-makers in sub-Saharan Africa perceive the importance of bovine brucellosis (14). When bovine brucellosis is considered purely based on its economic implications and its effect on animal health, governments in most African countries will rank its control as low compared to other animal diseases such as foot and mouth disease (FMD), rinderpest, contagious bovine pleuropneumonia (CBPP) and highly pathogenic avian influenza (HPAI), since bovine brucellosis does not result in acute fatalities and clear economic losses, although various workers have proved its economic significance (28).

Considering the public health implications alone, the disease is also given low priority compared to malaria, human immuno-deficiency virus (HIV) and tuberculosis. However, it is possible to raise the prioritisation of bovine brucellosis and increase the economic and public health benefits of control when both aspects are considered simultaneously (39). It will be more economically viable to associate bovine brucellosis control with the control of other important human and animal diseases. The 'one medicine' initiative – a situation in which intersectoral/multidisciplinary cooperation exists between human and veterinary medicine for the benefit of both human and animal health readily comes to play. This type of intersectoral cooperation has been used in times past to resolve many human and animal disease problems (25, 32, 33, 39). The WHO/ United Nations Children's Fund (UNICEF)-supported Expanded Program on Immunization (EPI) and Primary Health Care (PHC) programme to pastoralists in Sudan would not have achieved the level of success attained without intersectoral cooperation (32). Similar experiences were also witnessed among nomads during brucellosis control programmes in Chad and Mongolia (39).

In Nigeria, there is a yearly WHO/UNICEF-supported EPI or National Program on Immunization (NPI) to control six childhood killer diseases, namely: tuberculosis, polio, tetanus, whooping cough, diphtheria and measles. Providing this service to the nomadic population usually presents logistic problems due to the regular movements of nomadic populations which results in low coverage among pastoralists. High levels of success on the other hand have been achieved during mass vaccination against FMD or CBPP in the same pastoralist communities provided the *Ar'do* (head of the pastoralist/nomadic community) is informed. This example shows how valuable the animals are to the nomads (32, 39). It is possible to take advantage of this knowledge by combining the yearly child vaccination programme with a yearly cattle vaccination programme to achieve higher levels of success in both the human and animal populations, while sharing the cost in both sectors, thus making it more economically viable. To improve the relevance of brucellosis control, vaccination against brucellosis can be combined with vaccination against other diseases that are given more important, such as FMD, CBPP, rinderpest and the peste des petits ruminants (PPR).

Experience with Fulani cattle nomads in Nigeria have shown that the farmers will not allow bleeding of their animals unless they receive something in return (free vaccination or drugs). This is why most of the seroprevalence surveys for brucellosis in Nigeria are performed on blood obtained from abattoirs. The opportunity presented by a combined human-animal vaccination can be used to collect blood samples to conduct more accurate serological prevalence surveillance for bovine brucellosis and also to monitor the status of the disease.

Since it is often the wives of nomads who often handle milk from cattle, either to be used for domestic consumption or to be sold to create income for the family, the combined human animal vaccination programme can present an opportunity for extension services to women to encourage them to boil milk before consumption or sale. The programme can also help to generate research data in the form of questionnaires and structured interviews aimed at improving human and animal health.

Conclusion

The implementation of successful bovine brucellosis control/eradication programmes in sub-Saharan Africa are bedevilled by a number of challenges that do not exist in the northern hemisphere. It is concluded that the model used for the control of brucellosis, as proposed by the OIE in the *Terrestrial animal health code* , is impractical for sub-Saharan Africa and that this is the main reason that control does not exist. It is proposed that control strategies be redesigned to meet the needs of communal farming, low-income animal owners in countries that do not possess the required veterinary infrastructures.

Mass vaccination using strain S-19 or RB51 appear to be the most feasible methods to control brucellosis in sub-Saharan Africa but these campaigns have had limited success except in South Africa, Namibia and Zimbabwe. Vaccination is not practised probably because brucellosis is not a high priority in countries where veterinary services and funds are limited and used mainly for the control of transboundary diseases, such as FMD disease, East Coast fever and rinderpest (7). The use of vaccination has also been applied to wildlife but no vaccine has been shown to be applicable and effective for the control of brucellosis in wildlife.

A new model is required for control, increased biosecurity and different approaches to veterinary extension for farmers, medical personnel and policy makers should be adopted. Consequently, we propose an intersectoral/interdisciplinary approach, based on the 'One medicine' principles, for the control of bovine brucellosis in Nigeria and, by extension, in sub-Saharan Africa.

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